The Influence of Endogenous Nutrition Knowledge on Consumers' Willingness-T Pay for Grass-Fed Beef

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Abstract

The relationship between nutrition knowledge and consumers' food behavior has been debated for years. This may be partially attributed to the difficulty introduce by endogeneity of nutrition knowledge in econometric modeling. Using grass-fed beef as a vehicle, this paper investigates the impacts of consumers' nutrition knowledge on their willingness to pay by accommodating the endogeneity problem using instrumental variable approach. Our results suggest that consumers' nutrition knowledge significantly influences their willingness to pay for grass-fed beef. Gender and education are influential factors of consumers' nutrition knowledge level.

Introduction

Consumers' knowledge about the importance and usefulness of specific nutrients in a food product may influence their expectation of the product's health benefits which, in turn, affects their food consumption behavior. Given the mixed evidence in the current literature about the influence of nutrition knowledge on food behavior, this study intends to add understanding of the impact of nutrition knowledge on food consumption by assessing the influence of nutrition knowledge on consumers' willingness to pay for a nutritionally differentiated beef product - grass-fed beef.

There is possibility that consumers who offer higher WTP differ inherently from those offer lower WTP. As investigators, we are unable to observe all the factors that may be relevant to explain the differences. If some of these unobservables are correlated with consumers' nutrition knowledge in regression models, endogeneity bias will arise and the true effects of nutrition knowledge on consumers' WTP will be distorted. This study explores the possibility of using instrumental variables to tackle the problem.

Data

Cross-sectional data were collected through in-store non-hypothetical experiments in Virginia, West Virginia, Tennessee, and Kentucky in 2008.

Table 1: Data Summary

Description	Scale	Mean	S.D.	N
Willingness-To-Pay	>=0, continuous	0.7089	1.3607	404
Treatment B	1=Treatment B,0 otherwise	0.3614	0.4810	404
Treatment C	1=Treatment C,0 otherwise	0.2599	0.4391	404
Beef consumption frequency per week	Categorical, 1 - 3	2.3515	0.6062	404
Consumption experience about grass-fed beef	1=Yes, 0 otherwise	0.5767	0.4947	404
If the participant has ever been diagnosed with any of the five food-related diseases	1=Yes, 0 otherwise	0.5507	0.4970	404
If the participant's household member has ever been diagnosed with any of the five food-related diseases	1=Yes, 0 otherwise	0.7711	0.4206	404
Difference of lean meat color evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-0.8540	1.3718	404
Difference of fat color evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-0.3713	1.8307	404
Difference of meat texture evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	0.0693	1.8112	404
Difference of tenderness evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-0.3366	2.0851	404
Difference of juiciness evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	0	1.6921	404
Difference of flavor evaluation scores: conventional beef minus pasture-fed beef	-6 to 6	-.2921	1.6904	404
Respondent's gender	1=male; 0, otherwise	0.3358	0.6642	404
Participant's age	Categorical, 1 - 6	3.9035	1.5396	404
Marital status	1=single, 0 otherwise	0.1733	0.3790	404
Household size	>=1, integers	2.6485	1.3642	404
Education level	Categorical, 1 - 6	3.3342	1.5026	404
Household income level	Categorical, 1 - 11	4.7451	2.9151	404

Nutrition Knowledge and Consumers' WTP

Nutrition knowledge indexes are constructed based on two sets of indicator questions as listed in Table 2. One set measures consumers' familiarity with the functions of four specific nutrients - Vitamin A, Vitamin E, Omega 3 and CLA; the other set probes consumers' knowledge of the main food sources of these nutrients. The scores for knowledge about the nutrient functions and knowledge about the main food sources are obtained by adding up binary 0/1 scores assigned to the responses in each set.

Table 2: Nutrition Knowledge Measures

	Correct	Incorrect
Nutrient function knowledge		
(1) High levels of vitamin A in the body are toxic.	22%	78%
(2) Vitamin E can help protect against the development of cardiovascular disease and cancer.	53%	47%
(3) Omega 3 fatty acids can help reduce the risk of heart attacks.	62%	38%
(4) CLA (conjugated linoleic acid) has an anti-cancer effect.	12%	88%
Food source knowledge		
(1) Beta-carotene is a safe dietary source for vitamin A.	48%	52%
(2) Nuts and green leafy vegetables are good sources of Vitamin E.	58%	42%
(3) Canola and soybean oils are good sources of Omega 3 fatty acids.	49%	51%
(4) Butterfat and meat are good food sources of CLA.	12%	88%

We first estimate an OLS model and a Tobit model to provide a benchmark for the analysis. OLS estimates ignore the censoring problem in the WTP data and the potential endogeneity of nutrition knowledge, while the Tobit estimates take the censoring issue into account but still does not control for endogeneity.

Table 3: OLS and Tobit Estimation of WTP equation

	OLS		Tobit			
	Coef.	S.E	Coef.	S.E	Uncond.	Cond.
constant	0.58	0.51	-2.74	1.33		
tb	0.04	0.14	0.42	0.37	0.14	0.12
tc	0.10	0.15	0.26	0.40	0.08	0.07
freq	0.17*	0.10	0.43	0.27	0.14	0.12
pexperience	0.00	0.12	-0.16	0.32	-0.05	-0.04
disease	0.03	0.18	0.89*	0.53	0.29*	0.25*
kf	0.18***	0.07	0.54***	0.18	0.18***	0.15***
ks	-0.10*	0.06	-0.34**	0.16	-0.11**	-0.09**
dlcolor	-0.02	0.04	-0.02	0.12	-0.01	-0.01
dfcolor	0.00	0.04	-0.05	0.11	-0.02	-0.01
dtexture	0.07**	0.03	0.25***	0.09	0.08***	0.07***
dtender	0.13***	0.04	0.55***	0.12	0.18***	0.15***
djuicy	0.15***	0.05	0.42***	0.14	0.14***	0.12***
dflavor	0.11**	0.05	0.25**	0.12	0.08**	0.07**
gender	-0.18	0.13	-0.30	0.34	-0.10	-0.08
age	-0.08*	0.04	-0.07	0.11	-0.02	-0.02
single	-0.50***	0.19	-1.25**	0.52	-0.41**	-0.35**
famsize	-0.13**	0.05	-0.25*	0.14	-0.08*	-0.07*
ethnicity	0.40	0.28	0.37	0.76	0.12	0.10
edu	0.03	0.05	0.09	0.12	0.03	0.02
income	-0.02	0.02	-0.02	0.06	-0.01	0.00

Notes: (*) denotes statistical significance at least at a=0.1. (**) denotes statistical significance at least at a=0.05. (***) denotes statistical significance at least at a=0.01.

The results suggest the significant role of the two sets of nutrition knowledge on consumer WTP in both models.

Instrumental Variable Estimation

Lewbel (1997) higher-order instruments are constructed based the following functions:

(1) $r_1 = (WTP - \overline{WTP})^2$

(2) $r_2 = (KF - \overline{KF})^2$

(3) $r_3 = (KS - \overline{KS})^2$

(4) $r_4 = (WTP - \overline{WTP})(KF - \overline{KF})$

(5) $r_5 = (WTP - \overline{WTP})(KS - \overline{KS})$

The system of equations that we intend to estimate consists of a WTP function and two nutrition knowledge functions:

$$WTP = X\beta + \alpha_1 E_1 + \alpha_2 E_2 + S\gamma_1 + u_1$$
$$E_1 = E(N;S) = N\delta_{21} + S\gamma_{21} + u_2$$
$$E_2 = E(N;S) = N\delta_{31} + S\gamma_{31} + u_3$$

. Following Smith and Blundell (1986), we can express

$$u_1 = \theta_1 u_2 + \theta_2 u_3 + e_1$$
$$\theta_1 = \frac{\mathrm{cov}(u_1, u_2)}{\mathrm{var}(u_2)} \qquad \theta_2 = \frac{\mathrm{cov}(u_1, u_3)}{\mathrm{var}(u_3)}$$

We have

$$WTP = X\delta_1 + \alpha_1 E_1 + \alpha_2 E + S\gamma_1 + \theta_1 u_2 + \theta_2 u_3 + e_1$$

Table 4: Lewbel Instrument Estimates of Reduced Form Equations of Nutrition Knowledge

	Nutrition knowledge of nutrient functions		Nutrition knowledge of nutritious food sources	
	Coefficient	Std. Error	Coefficient	Std. Error
constant	0.26	0.44	1.00	0.54
r1	0.01	0.01	-0.01	0.01
r2	0.25***	0.04	0.04	0.04
r3	-0.09***	0.04	0.07	0.05
r4	-0.02	0.04	0.05	0.05
r5	-0.05	0.04	-0.12**	0.05
tb	0.12	0.12	0.01	0.14
tc	0.00	0.13	0.08	0.16
freq	0.08	0.09	0.15	0.11
experience	0.22**	0.10	0.31**	0.13
disease	-0.02	0.16	-0.04	0.19
dlcolor	0.03	0.04	0.06	0.05
dfcolor	-0.02	0.04	-0.10**	0.04
dtexture	0.01	0.03	0.00	0.04
dtender	0.02	0.03	-0.02	0.04
djuicy	0.09**	0.04	0.02	0.05
dflavor	0.00	0.04	0.04	0.05
gender	-0.21*	0.11	-0.40***	0.13
age	0.03	0.04	0.01	0.05
single	0.23	0.16	0.09	0.20
famsize	0.00	0.05	-0.06	0.06
ethnicity	0.06	0.24	-0.17	0.30
edu	0.20***	0.04	0.16***	0.05
income	-0.02	0.02	-0.02	0.03
Partial R2	0.12		0.02	
Shea Partial R2	0.15		0.03	
F(5, 378)	10.71		1.89	

Notes: (*) denotes statistical significance at least at a=0.1. (**) denotes statistical significance at least at a=0.05. (***) denotes statistical significance at least at a=0.01.

Squared partial correlation, Shea's partial correlation , and F-test all suggest the relevance between instruments and endogenous knowledge variables. Under-identification tests using the Anderson (1985) canonical correlations and the Cragg-Donald (1993) statistics reject the null that the model is under-identified (a =0.05). Sargan's (1958) test also indicates the validity of the instruments used (a = 0.01).

Results

Table 5 present the Tobit estimates of the two-stage IV estimation. In WTP equation, the significant coefficients of the residuals obtained from the first-stage estimation strongly indicate the existence of endogeneity of nutrition knowledge (a = 0.01) in the structural model.

Table 5: Two Stage Tobit Estimates

Variable	Coefficient	S.E.	Unconditional expected value	Conditional on being uncensored
constant	-0.21	1.54		
tb	0.17	0.36	0.06	0.05
tc	0.25	0.38	0.08	0.07
freq	0.66**	0.29	0.22**	0.18**
experience	0.38	0.37	0.12	0.11
disease	0.78	0.52	0.26	0.22
kf	1.96***	0.41	0.64***	0.54***
ks	-3.09***	0.88	-1.02***	-0.86***
dlcolor	0.13	0.13	0.04	0.04
dfcolor	-0.29**	0.13	-0.10**	-0.08**
dtexture	0.22***	0.09	0.07***	0.06***
dtender	0.44***	0.12	0.14***	0.12***
djuicy	0.37***	0.13	0.12***	0.10***
dflavor	0.35***	0.12	0.12***	0.10***
gender	-1.04**	0.44	-0.34**	-0.29**
age	-0.07	0.11	-0.02	-0.02
single	-1.31***	0.51	-0.43***	-0.36***
famsize	-0.40***	0.14	-0.13***	-0.11***
ethnicity	0.16	0.75	0.05	0.04
edu	0.20	0.16	0.06	0.05
income	-0.05	0.06	-0.02	-0.01
resid1	-1.64***	0.45	-0.54***	-0.46***
resid2	2.73***	0.83	0.90***	0.76***
Log likelihood	-372.15			
LR chi2(22)	218.6			
Pseudo R2	0.23			

Notes: (*) denotes statistical significance at least at a=0.1. (**) denotes statistical significance at least at a=0.05. (***) denotes statistical significance at least at a=0.01.

Conclusion

The Tobit estimates suggest significant effects of nutrition knowledge and sensory evaluation on consumers' WTP. The two sets of the nutrition knowledge exhibit opposite influences on consumers' WTP for grass-fed beef: knowledge about nutrient functions positively affects consumers' WTP, while the impact of knowledge about the nutritious food sources on consumers' WTP for grass-fed beef is negative.

Our results indicate that the endogeneity of nutrition knowledge could downwardly bias the OLS and Tobit estimates. If nutrition educators assess the impacts of nutrition knowledge on consumers' food purchasing behavior without taking into account the potential endgeneity issues, the impacts could be under-estimated. Consequently, the influential role of nutrition education in motivating healthier diets may not be revealed.